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Indian Standard

SPECIFICATION FOR DC PERIODMETERS
(IEC Title : DC Periodmeters : Characteristics and Test Methods)

UDC 621·317·39 : 621·039·564

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 8

April 1987

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National Foreword

This Indian Standard, which is identical with IEC Pub 295 (1969) 'DC Periodmeters : Characteristics and Test Methods' issued by the International Electrotechnical Commission was adopted by the Indian Standards Institution on the recommendation of the Nuclear Instrumentation Sectional Committee and approval of the Electronics and Telecommunication Division Council.

Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

Cross References

In this Indian Standard, the following International Standards are referred to. Read in their respective places the following:

International Standard	*Corresponding Indian Standard*
IEC Pub 181(1964) Index of electrical measuring used in connection with ionizing radiation	IS : 11600-1985 Index of electrical measuring apparatus used in connection with ionizing radiation

The technical committee responsible for the preparation of this Indian Standard has reviewed the provisions of the following IEC standards and has decided that they are acceptable for use in conjunction with this standard.

IEC Pub 231 (1967) General principles of nuclear reactor instrumentation.

IEC Pub 232 (1966) General characteristics of nuclear reactor instrumentation.

Only the English language text of the International Standard has been retained while adopting it in this Indian Standard.

Adopted 28 August 1985 Gr 8

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CONTENTS

INTRODUCTION

a) Interpretation of this Recommendation

The moods of verbs used in this Recommendation have the following implications:

Mandatory

— In English: "shall" or "must".

Recommendation

— In English: "should".

Acceptable method, example of good practice

— In English: "may".

Alternatively, the item may be titled "Acceptable method" or "Example of good practice".

b) Terminology

In this Recommendation, conditions required by the user are termed "specified" and information to be supplied by the manufacturer is termed "given" or "stated".

SECTION ONE — GENERAL

Scope

The aim of the present Recommendation is to establish recommendations concerning the particular characteristics and test methods of d.c. periodmeters. (General characteristics and principles are given in IEC Publications 231, General Principles of Nuclear Reactor Instrumentation, and 232, General Characteristics of Nuclear Reactor Instrumentation.)

A periodmeter is an "electronic sub-assembly which, in association with one or more detectors, is used to indicate the time constant (period) of a nuclear reactor. Its indication may be given in units of time-constant, doubling time, decades per minute, etc." (IEC Publication 181, Index of Electrical Measuring Apparatus used in connection with Ionizing Radiation, definition 305-020.)

In particular, the d.c. periodmeter is a sub-assembly used in combination with a radiation detector to:

— measure on a logarithmic scale the neutron flux Φ of a nuclear reactor;

— provide an indication of the time constant (period) T determined by an equation of the form:

$$\frac{1}{T} = \frac{d}{dt} \log_e \left(\frac{\Phi}{\Phi_0} \right) = \frac{1}{\Phi} \frac{d\Phi}{dt}$$

where:

Φ_0 is a constant with dimension of neutron flux.

The periodmeter considered in this Recommendation consists essentially of:

— a d.c. log amplifier with a voltage output, including possibly a preamplifier and connecting cable. In the following, this assembly is treated as a unit and termed "amplifier";

— a time derivative unit with a voltage output.

SECTION TWO — ELECTRICAL CHARACTERISTICS

2. D.C. log amplifier

2.1 *Principle*

A d.c. log amplifier is a basic function unit which, for an input current I_1, develops an output voltage:

$$V_2 = A \log_{10} \frac{I_1}{I_0} \tag{1}$$

where:

A is a constant expressed in volts per decade of the input current

I_0 is the input current which produces a zero output voltage.

The current I_1 is the output of a radiation detector: it should be proportional to the flux Φ to which the detector is subjected.

2.2 *Measurement range*

The measurement range of a d.c. log amplifier is defined by the limits of the input current between which the instrument conforms to the specifications hereafter. The range is expressed by these limit values:

— I_{1m} minimum input current;

— I_{1M} maximum input current,

to which the output voltages V_{2m} and V_{2M} correspond.

The errors associated with the log amplifier are given in terms of output voltage. To a small variation ΔI, corresponds a variation ΔV_2 such that:

$$\frac{\Delta I}{I} = \frac{1}{A} \frac{\Delta V_2}{\log_{10} e}$$

2.3 *Static error*

The static error is defined by the difference between the output signal V_2 and the input signal expressed in terms of a calculated output voltage V_{21}.

The static error is expressed in per cent by the equation:

$$E_{sa} = 100 \frac{V_2 - V_{21}}{A}$$

where:

V_2 is the measured output voltage when I_1 is the input current

V_{21} is computed from equation (1).

2.4 *Response time*

The response time of a log amplifier is the time taken by the output signal to attain, for the first time, 90% of the final value of the incremental change in the output voltage measured from the instant of addition of an input current step of 9 I_1 to an initial value of I_1. This response time shall be stated for each decade of the input current. The input circuit characteristics, in particular its capacitance, shall be those specified under test methods in Section Three of this Recommendation.

2.5 *Dynamic error*

The dynamic error is defined as the maximum value attained by the ratio:

$$\frac{\Delta V_2}{A}$$

where:

ΔV_2 is the difference between the output signal and the input signal expressed in units of output voltage when the input current I_1 varies according to an exponential law:

$$I_1 = I_{1_0} e^{t/T_s}$$

where:

I_{1_0} is the initial current

T_s is the time constant of the injected signal.

The dynamic error is expressed in per cent by:

$$E_{da} = 100 \left. \frac{\Delta V_2}{A} \right|_{max}$$

The input circuit characteristics, in particular its capacitance, shall be those specified under test methods in Section Three.

The dynamic error shall be stated, in particular for the current $I_{1_0} = I_{1m}$ and for $T_s = T_M$ which is the time constant corresponding to the extreme of the periodmeter measurement range for positive periods.

2.6 *Amplitude of output signal fluctuation due to purely electronic causes*

The amplitude of output signal fluctuation due to purely electronic causes, expressed in per cent, is defined by:

$$F_a = 100 \frac{\delta V_2}{A}$$

where:

δV_2 is the maximum peak-to-peak deviation of the output signal, when an input current I_1 is injected by a d.c. generator. The value of δV_2 shall be determined after a reasonable period of observation, which shall be stated.

Input circuit characteristics, in particular its capitance, shall be those specified under test methods in Section Three.

The amplitude of output signal fluctuation due to purely electronic causes shall be stated for several input current values and, in particular, for I_{1m} and I_{1M}.

2.7 *Drift*

The drift, expressed in per cent, is defined for a constant input current and a constant ambient temperature by:

$$D_a = 100 \frac{\Delta V_2}{A}$$

where:

ΔV_2 is the difference between the maximum and minimum values of the recorded average output signal when an input current I_1 is injected by a d.c. generator.

Drift shall be stated per hour, per 24 h and per week after a warm-up time and for measurement range limit values I_{1m} and I_{1M}.

2.8 *Output variation due to temperature*

The output variation due to temperature, expressed in per cent, is defined for a constant input current by:

$$V_{ta} = 100 \frac{\Delta V_2}{A}$$

where:

ΔV_2 is the difference between the maximum and minimum values of the recorded average output signal, when an input current I_1 is injected by a d.c. generator and the ambient temperature is changed within specified limits.

Test conditions shall be given, particularly input circuit characteristics.

Output variation due to temperature shall be stated for measurement range limit values I_{1m} and I_{1M}.

2.9 *Output variation due to mains voltage*

The output variation due to mains voltage, expressed in per cent, is defined for a constant input current and a constant ambient temperature by:

$$V_{ua} = 100 \frac{\Delta V_2}{A}$$

where:

ΔV_2 is the difference between the maximum and minimum values of the recorded average signal, when an input current I_1 is injected by a d.c. generator and the mains voltage is changed within specified limits.

The output variation due to mains voltage shall be stated for measurement range limits I_{1m} and I_{1M}.

2.10 *Output variation due to mains frequency*

Same as Sub-clause 2.9, but the mains frequency is changed within specified limits.

2.11 *Output variation due to load*

The output impedance shall be such that the accuracy specifications are met for all load currents no greater than a specified value.

The maximum capacitance which may be connected to the output shall be stated.

2.12 *Output variation due to humidity*

Under consideration.

3. Time derivative unit

3.1 *Principle*

A time derivative unit develops an output voltage V_3 which is proportional to the time derivative of the input voltage V_2, according to the equation:

$$V_3 = k \frac{dV_2}{dt} + V_{3_0} \qquad (2)$$

where:

k is a coefficient with the dimension of time and a specified tolerance

V_{3_0} is the output signal for a constant input signal (infinite period of periodmeter).

3.2 *Measurement range*

The limits of the measurement range of a time derivative unit are the extreme values expressed by the term:

$$\frac{dV_2}{dt}$$

of equation (2).

If the output signal is a voltage proportional to the inverse of the period $1/T$, the measurement range is expressed by T_m and T_M.

T_M is the time constant corresponding to the extreme of the periodmeter measurement range for positive periods and T_m for negative periods.

3.3 *Response time and overshoot*

The response time of a time derivative unit is the time taken by the output signal to attain, for the first time, 90% of its final value measured from the instant t_0 at which the linearily rising voltage is injected at its input. The amount of overshoot beyond the final amplitude of the output signal shall be stated in per cent of this amplitude.

If the response time and overshoot beyond the final amplitude of the output signal are functions of the slope of the rising voltage injected at the time derivative unit input and of its initial value they shall be stated as such and their maximum values shall be given.

3.4 *Amplitude of output signal fluctuation due to purely electronic causes*

The amplitude of output signal fluctuation, expressed in per cent, is defined by:

$$F_{\mathrm{d}} = 100 \frac{\delta V_3}{V_{3\mathrm{M}}}$$

where:

δV_3 is the maximum peak-to-peak deviation of the output signal with the time derivative unit input terminated in a specified impedance typical of the log amplifier output impedance

$V_{3\mathrm{M}}$ is the output voltage corresponding to limit T_{M} of the measurement range.

δV_3 is determined after a reasonable duration of observation which shall be stated.

3.5 *Drift*

The drift, expressed in per cent, is defined for a constant input signal and a constant ambient temperature by:

$$D_{\mathrm{d}} = 100 \frac{\Delta V_3}{V_{3\mathrm{M}}}$$

where:

ΔV_3 is the difference between the maximum and minimum values of the recorded average output signal

$V_{3\mathrm{M}}$ is the output voltage corresponding to limit T_{M} of the measurement range.

Drift shall be stated per hour, per 24 h and per week after a warm-up time.

3.6 *Output variation due to temperature*

The output variation due to temperature, expressed in per cent, is defined for a constant input signal by:

$$V_{\mathrm{td}} = 100 \frac{\Delta V_3}{V_{3\mathrm{M}}}$$

where:

ΔV_3 is the difference between the maximum and minimum values of the recorded average output signal when the ambient temperature is changed within specified limits

$V_{3\mathrm{M}}$ is the output voltage corresponding to limit T_{M} of the measurement range.

Te t conditions and, in particular, the input circuit characteristics shall be stated.

3.7 *Output variation due to mains voltage*

The output variation due to mains voltage, expressed in per cent, is defined for a constant input signal and a constant ambient temperature by:

$$V_{ud} = 100 \frac{\Delta V_3}{V_{3M}}$$

where:

ΔV_3 is the difference between the maximum and minimum values of the recorded average output signal when the mains voltage is changed within specified limits

V_{3M} is the output voltage corresponding to limit T_M of the measurement range.

Test conditions and, in particular, the input circuit characteristics shall be stated.

3.8 *Output variation due to mains frequency*

Same as Sub-clause 3.7, but the mains frequency is changed within specified limits.

3.9 *Output variation due to load*

The output impedance shall be such that the accuracy specifications are met for all load currents not greater than a specified value.

The maximum capacitance which may be connected to the output shall be stated.

3.10 *Output variation due to humidity*

Under consideration.

4. **Periodmeter**

4.1 *Principle*

A d.c. periodmeter is a sub-assembly which gives an output signal V_3 determined by the equation:

$$V_3 = \frac{k\ A \log_{10} e}{T} + V_{3_0} \qquad (3)$$

when the input current I_1 varies according to an exponential law:

$$I_1 = I_{1_0}\, e^{t/T}$$

4.2 *Response time and overshoot*

The response time of a periodmeter is the time taken by the output signal of the time derivative unit to attain, for the first time, 90% of its final value after injection of an input current I_1 according to the law:

$$I_1 = I_{1_0}\, e^{t/T_s}$$

where:

I_{1_0} is a stated initial current

T_s is the time constant (period) of the injected signal.

The amplitude of the output signal overshoot shall be stated.

If response time and overshoot are functions of initial current I_{1_0} or period T_s, they shall be stated as such. They shall be stated in particular for initial current values I_{1_0} lower than the minimum I_{1m} of the measurement range of the log amplifier and for periods between T_M and 10 T_M.

Input circuit characteristics and, in particular, the capacitance shall be given.

4.3 *Response to a fast-rising transient input signal*

The response to a fast-rising transient input signal of a periodmeter is defined for positive periods shorter than T_M in terms of the delay introduced by the periodmeter in reaching the limit T_M of the measurement range after the injection of an input current whose variation is given by:

$$I_1 = I_{1_0}\, e^{t/T_s}\ .$$

where I_{1_0} and T_s are specified.

The form of the curve of the output signal versus time during the transient until recovery shall be given.

4.4 *Amplitude of output signal fluctuation due to purely electronic causes*

The amplitude of output signal fluctuation of a periodmeter due to purely electronic causes, expressed in per cent, is defined for a constant input current, a constant mains voltage and a constant ambient temperature by:

$$F_p = 100\, \frac{\delta V_3}{V_{3M}}$$

where:

δV_3 is the maximum peak-to-peak deviation of the output signal

V_{3M} is the maximum value of the output signal and corresponds to the limit T_M of the periodmeter measurement range.

The amplitude of output signal fluctuation shall be stated for several input current values and, in particular, for I_{1m} and for zero input current.

Input circuit characteristics and, in particular, the capacitance shall be stated.

SECTION THREE — TEST METHODS

5. General standard test conditions

5.1 *Influence conditions*

Unless specified otherwise, it is necessary that the tests on the units and complete periodmeter shall be conducted so as to show that the characteristics are maintained:

- when ambient temperature varies from + 10 °C to + 45 °C (relative humidity between 45% and 75%), although reduced performance may be acceptable between the wider limits 0 °C and + 55 °C;
- from an a.c. mains with voltage variations from — 12% to + 10% of the nominal value, or from a d.c. mains with voltage variations from — 5% to + 15% of the nominal value;
- with maximum output current.

The actual atmospheric conditions shall be stated on the test sheet. In conformity with good practice, they shall not be subject to large or rapid variations during a series of measurements. A practical method to avoid such variations is to place the instrument in a climatic chamber at constant temperature of + 30 °C.

5.2 *Warm-up time*

Measurements shall be carried out after a period of continuous operation at least equal to that stated by the manufacturer. If not specified, the warm-up time shall be 1 h for instruments using electronic tubes and 30 min for other instruments.

5.3 *Position*

The test position shall be that of normal use.

6. D.C. log amplifier

All the tests described below shall be performed with a capacitance in parallel with the input. The value of this capacitance shall be stated for each measurement.

6.1 A *and* I_0 *constants*

The test begins after a warm-up time.

The input current is obtained from a low noise current generator, whose accuracy is no worse than ± 2% for currents greater than 10^{-11} A and ± 5% for currents less than 10^{-11} A. In this test, the calibration currents are supplied by the generator.

The d.c. log amplifier is adjusted with calibrated currents, noting accurately the output voltage.

Output voltages V_2 are measured corresponding to applied input currents I_1 at least each decade.

For example, coordinate points (I_1, V_2) may be plotted using a logarithmic abcissa and linear ordinate, and a straight line representing the functional relation:

$$V_2 = A \log_{10} \frac{I_1}{I_0}$$

is drawn within the normal measurement range of the amplifier.

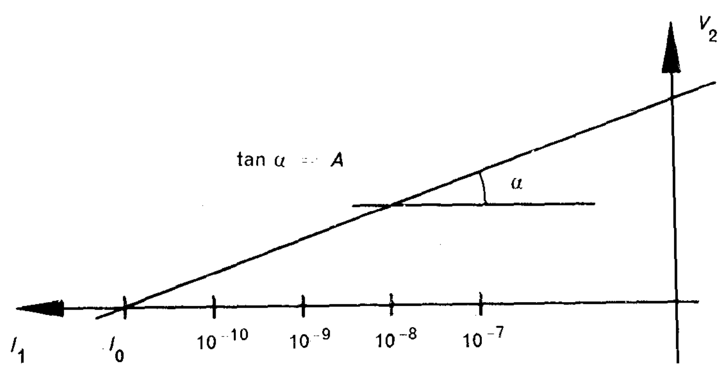

FIGURE 1

The constant A, in volts per decade, is equal to the slope of the straight line:

$$A = \frac{\Delta V_2}{\Delta(\log_{10} I_1)}$$

A may be positive or negative.

The straight line is extrapolated to its intersection with the I_1 axis.

The corresponding value of I_1 is I_0.

6.2 *Measurement range and static error*

Same test method as in Sub-clause 6.1.

Voltage V_2 corresponds to the measured quantity and V_{21} corresponds to a point on the straight line for an input current I_1.

Static error is calculated as given in Sub-clause 2.3.

The accuracy of an internal calibration current, I_c, is measured by comparing the output voltage V_c, corresponding to I_c, with the output voltage V_s, corresponding to a standard current, I_s, obtained from a high accuracy standard current generator.

Calibration current accuracy is calculated as given in Sub-clause 2.3.

6.3 *Response time*

The input current $9\ I_1$, added to the initial value I_1, is injected at a given instant. The time is measured as given in Sub-clause 2.4.

The response time shall be stated for each decade of input current.

Measurement may be made using a high-speed recorder or oscilloscope.

In the case of addition of a very low current step (by resistance), it is necessary to ensure that the effects of parasitic capacitance do not affect the measurement.

In this test method, the characteristics of input signal injected in practice and the injecting device, if any, shall be stated.

6.4 *Dynamic error*

The current I_1 is injected according to the exponential law given in Sub-clause 2.5.

The output signal is recorded, for example, with a high-speed recorder.

The dynamic error is calculated as given in Sub-clause 2.5.

6.5 *Amplitude of output signal fluctuation due to purely electronic causes*

The input current I_1 is obtained from a low noise current generator.

The peak-to-peak amplitude δV_2 of the amplifier output signal is measured, for example, with an oscilloscope sensitive from zero frequency to several megahertz, and a normal spot brilliancy.

The amplitude of output signal fluctuation is calculated as given in Sub-clause 2.6.

6.6 *Drift*

The input current I_1 is obtained from a low noise current generator with stability equal to 1% or better.

Drift measurement of the d.c. log amplifier is performed at an ambient temperature of 30 ± 2 °C and begins after a warm-up time at this temperature. The amplifier shall be off for at least 24 h prior to warm-up.

Amplifier output signal variation ΔV_2 may be measured, for example, with a millivolt recorder.

The drift is calculated as given in Sub-clause 2.7.

6.7 *Output variation due to temperature*

Same test method as for drift but the temperature is varied from 25 °C to 35 °C and from 10 °C to 45 °C. Prior to each output signal measurement, the temperature shall be held constant for at least half an hour.

The output variation due to temperature is calculated as given in Sub-clause 2.8.

6.8 *Output variation due to mains voltage*

Same test method as for drift, but the mains voltage is varied within limits specified in Sub-clause 5.1; dynamic effects are neglected.

Output variation due to mains voltage is calculated as given in Sub-clause 2.9.

6.9 *Output variation due to mains frequency*

Same test method as for drift, but the mains frequency is varied $\pm$ 2% about its specified nominal value.

Output variation due to mains frequency is calculated as given in Sub-clause 2.10.

6.10 *Output variation due to load*

Same test method as for drift, but the output load current is varied from 0% to 100% of its maximum value.

Output impedance value is:

$$Z_a = \frac{\Delta V}{\Delta(\text{load current})}$$

6.11 *Output variation due to humidity*

Under consideration.

7. **Time derivative unit**

7.1 k *and* V_{3_0} *constants*

The input voltage is injected with a ramp voltage generator whose accuracy shall be no worse than $\pm$ 2%, and output voltages corresponding to rising voltages with rates of change within limits of normal operation of the unit are measured.

For example, the coordinates:

$$\left(\frac{dV_2}{dt}, V_3\right)$$

may be plotted using linear coordinates. The straight line, representing the functional relation (2) given in Sub-clause 3.1 is then drawn within the measurement range of the unit.

The constant k is equal to the slope of the straight line and V_{3_0} is the ordinate at:

$$\frac{dV_2}{dt} = 0$$

7.2 *Measurement range*

Same test method as in Sub-clause 7.1.

Negative and positive limit values of $\frac{dV_2}{dt}$ as defined in Sub-clause 3.2 are noted.

7.3 *Response time and overshoot*

In the general case where the response time of the time derivative unit depends on the initial value and the rate of change of the input voltage, the corresponding output curve is plotted for each initial value and for each rate of change selected.

The time derivative unit input is connected to an adjustable initial voltage and a ramp voltage of constant rate is injected for each different initial value.

For example, output signal may be recorded with a high-speed recorder.

The response time and overshoot are obtained from this recording.

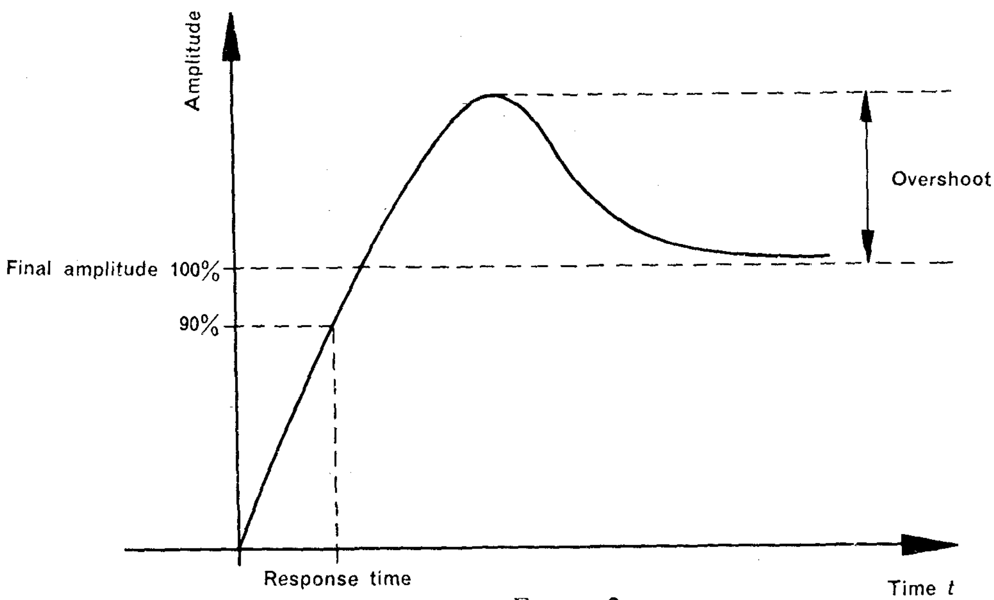

FIGURE 2

7.4 *Amplitude of output signal fluctuation due to purely electronic causes*

The peak-to-peak amplitude δV_3 of the output signal of the time derivative unit, whose input shall be connected to an impedance equal to the output impedance of the log amplifier, may be measured, for example, with an oscilloscope sensitive from zero frequency to several megahertz and a normal spot brilliancy.

The amplitude of output signal fluctuation is calculated as given in Sub-clause 3.4.

7.5 *Drift*

The drift measurement of the time derivative unit is performed at an ambient temperature of 30 $\pm$ 2 °C and begins after a warm-up time at this temperature. The time derivative unit shall be off for at least 24 h prior to warm-up.

The input of the time derivative unit shall be connected to an impedance equal to the output impedance of the log amplifier.

The output signal variation ΔV_3 may be measured, for example, with a millivolt recorder.

The drift is calculated as given in Sub-clause 3.5.

7.6 *Output variation due to temperature*

Same test method as for drift, but the temperature is varied from 25 °C to 35 °C and from 10 °C to 45 °C. Prior to each output signal measurement, the temperature shall be held constant for at least half an hour.

Output variation due to temperature is calculated as given in Sub-clause 3.6.

7.7 *Output variation due to mains voltage*

Same test method as for drift, but the mains voltage is varied as specified in Sub-clause 5.1; dynamic effects are neglected.

Output variation due to mains voltage is calculated as given in Sub-clause 3.7.

7.8 *Output variation due to mains frequency*

Same test method as for drift, but the mains frequency is varied $\pm$ 2% about its specified nominal value.

Output variation due to mains frequency is calculated as given in Sub-clause 3.8.

7.9 *Output variation due to load*

Same test method as for drift, but, with output voltages corresponding to T_m and T_M, the output load current is varied from 0% to 100% of its maximum value.

Output impedance value is:

$$Z_d = \frac{\Delta V}{\Delta(\text{load current})}$$

7.10 *Output variation due to humidity*

Under consideration.

8. **Periodmeter**

All the tests described below are performed with the same capacitance in parallel with the input of the log amplifier and the value of this capacitance shall be stated with each measurement.

Tests may be carried out with several capacitance values.

8.1 *Noise measurement without radiation (without flux)*

The input of the amplifier, or preamplifier when it exists, is connected to a low noise current generator able to supply decade currents within the over-all d.c. log amplifier range.

The high voltage supplies are each connected to the input-plug pin corresponding to the collector electrode by a capacitor equal to the detector interelectrode capacitance.

8.2 *Noise measurement with radiation (with flux)*

The input of the amplifier, or preamplifier when it exists, is connected to a neutron ionization chamber having given characteristics and whose type, consistent with the periodmeter considered, shall be stated with the test results.

This chamber is irradiated by a stated neutron flux such that it is able to operate in the first decade of the d.c. log amplifier. Moreover the neutron source used shall not induce fluctuations which would increase the shot effect of the detector.

For each of the two previous tests, the peak-to-peak noise voltage of the output may be measured, for example, with an oscilloscope sensitive from zero frequency to several megahertz and a normal spot brilliancy.

Equivalent period noise is calculated by the formula:

$$T = \pm \frac{2\ \mathrm{k}\ A \log_{10} \mathrm{e}}{\delta V_3}$$

where:

δV_3 is the peak-to-peak noise voltage.

8.3 *Response time and overshoot*

The exponential current given in Sub-clause 4.2 is injected into the input of the d.c. log amplifier previously in stand-by position with initial current I_{1_0}.

The periodmeter output may be connected, for example, to a d.c. oscilloscope.

Starting from $I_{1_0} = I_{1m}$ the initial current is increased in decades and the operator notes, for several values of T_s, from T_M to 10 T_M:

a) the time taken by the output signal to attain 90% of its stable final value;

b) if overshoot appears, the value of the overshoot expressed as a percentage of final amplitude.

8.4 *Response to fast rising transient input signal*

The exponential current given in Sub-clause 4.3 and covering a range of three decades is injected into the input of the d.c. log amplifier previously in stand-by position with initial current I_{1_0}

The periodmeter output may be connected, for example, to a recorder.

Starting from:

$$I_{1_0} = 10^{-2}\ I_{1m}$$

the transient until recovery is recorded for a value of $T_s = 0.1\ T_M$. The starting current is increased in one decade increments and the measurement is repeated.

The *response time* is the time taken by the output signal to reach the end of the measurement range, T_M, and is measured from the time when the exponential current is injected.

The *recovery time* is the time taken by the output signal to return to the beginning of the measurement range (infinity) and is measured from the time when the exponential current generator is stopped.

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APPENDIX

EXAMPLES OF PERIODMETER CHARACTERISTICS

Under consideration.